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Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

February 4, 1987

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Our ref: 863-2041

Manville Service Corporation
Mail Stop 3-25
12999 Dear Creek Canyon Road
Littleton, CO 80127

U.S. EPA, Region V
WASTE MANAGEMENT DIVISION
HAZARDOUS WASTE CONTROL SECTION

ATTENTION: Mr. Marvin Clumpus, P.E., Senior Engineer

RE: UPFREEZING ANALYSIS--TWO-LAYER, 21-INCH COVER
WAUKEGAN, ILLINOIS PLANT WASTE DISPOSAL AREA

Dear Mr. Clumpus:

Ref: Golder Associates December 19, 1986 Letter to Manville Service Corporation, "Updated Upfreezing Cover Thickness Analysis -- Using McGaw (EPA) Thermal (Lambda, N, K) Values..." and including attached UPFREEZ5Y results, dated 12-18-86

This extends the upfreezing analysis results in the referenced December 19 letter in answer to your question regarding the upfreezing performance and R100 estimate for a two-layer, 21-inch cover described as follows:

Upper Layer: 12 inches of silty clay, identical to the cover soil assumed in the December 19 letter, and having $S = 30\%$ and $F = 0.3$;

Lower Layer: 9 inches of sand, presumably NFS (non-frost-susceptible) but having $S = 10\%$ and $F = 0.3$.

R100 is the estimated probability (reliability) that upfreezing of "critically sized" (i.e., $X - A \leq 0.3$ ft) asbestos particles initially at the worst-case location (top of waste pile or bottom of cover) will take 100 years or longer. Cover upfreezing performance, including R100, was assessed based on thermal and upfreezing analysis, described as follows.

Cover Thermal Analysis

The December 19 results (including UPFREEZ5Y output) show the estimated thermal capacity of the upper 12-inch silty clay layer (S=30%) to be 667 F-Degree Days \pm 14%. The estimated partial freezing index of the sand layer is about 640 F-Degree Days, assuming an unfrozen dry density of 110 pcf, S=10%, and thermal property relationships consistent with those in UPFREEZ5Y.

Therefore, the assumed 21-inch two-layer cover has a total thermal capacity of about 1,310 F-Degree Days. This is thermally equivalent to a 1.4-ft (17-inch) one-layer silty clay cover, which the UPFREEZ5Y output shows to have an estimated thermal capacity of 1308 F-Degree Days and an expected (average) return period of nine (9) years for complete freezing of the cover.

R100 (100-Year Reliability) Estimate

R100 for the assumed two-layer, 21-inch cover is 100%. That is, with the assumed S and F values, the absolute lower bound (ABD in UPFREEZ5Y) for upfreezing of critically sized particles exceeds 100 years, and, in fact, exceeds 120 years (83 or more years in the sand then 37 years in the silty clay). Based on comparison with 12-18-86 UPFREEZ5Y results: (1) the absolute lower bound is closer to 162 years (about 125 years through the sand then 37 years through the silty clay), and (2) the average or expected value for upfreezing (UP.YRS IN UPFREEZ5Y) would exceed 1,000 years. Regardless of the precise absolute lower bound estimate, for the assumed two-layer, 21-inch cover: R100 = 100%.

R100 estimates are conditional on strain (S) and heave fraction not recovered on thawing (F). Taken as a pair, the S and F values assumed or hypothesized for the cover are considered to conservatively and realistically support the R100 = 100% estimate. First, the assumed F=0.3 is considered conservative because empirical upfreezing studies show F to be of order 0.1 for vertical motion (August 25, 1986 personal communication from Prof. Bernard Hallet, Director of the Periglacial Laboratory at the University of Washington Quaternary Research Center). Second, the assumed S values for the two-layer cover are considered very conservative for this site, as discussed next.

Sand Layer-Related Upfreezing Characteristics

Visual inspection and limited sampling and grain-size testing indicate the natural clean sands found on site are medium to fine sand with less than one percent passing the No. 200 sieve, classified SP by the Unified Soil Classification System and NFS (non-frost-susceptible) by the U.S.A. Corps of Engineers frost design criteria. If, in fact, the cover sand layer is composed of these or similar sands, placed and

maintained uncontaminated by fines, then strain, S, will be less than 10%. Most likely S will be 3% or less, and very conceivably zero because freezing can drive water out of clean sands (in open systems) where drainage can occur.

At this site it is considered likely that drainage conditions below and laterally around the sands will allow drainage of freezing-expelled water from the (clean) sands because of the relatively slow advance of the freeze front in the sand layer (insulated below the 12 inches of silty clay). Therefore, provided adequate surface drainage is maintained to control ponding, an S=10% assumption for the sand layer is considered extremely conservative.

Further, the sand will reduce frost heaving in the silty clay due to moisture migration from below the silty clay (i.e., from the waste pile or the sand itself). The sand layer will also help provide (gravity) drainage to the silty clay. Therefore, a significant reduction in the strain (S) of the silty clay can be expected because of the sand. Under these circumstance an S=30% assumption for the silty clay is considered very conservative.

Conclusion

The assumed two-layer, 21-inch cover, actually implemented and maintained with good design (as assumed here), realistically and conservatively supports the R100=100% estimate and, for practical purposes, can be expected to stop upfreezing of critically sized particles.

Thank you for the opportunity to be of help. Please call if you need any clarification, elaboration, or further discussion.

Sincerely,

GOLDER ASSOCIATES



Charles L. Vita, P.E.
Senior Project Manager

CLV/cmw/034

cc: Brad Bradley, EPA (Region V, Chicago, IL)
Richard McGaw, (Hanover, NH)